Improvement of the Design Process of Assembly Equipment for Aircraft Engines

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Abstract

This project focused on improving the design process for aircraft engine assembly and disassembly equipment within an aerospace engineering department. The existing process was structured around broad phases without detailed activity definitions, resulting in inconsistent execution, process variability and frequent rework. The objective was to redesign the workflow by developing a detailed, standardized process flow map. The methodology followed the PDCA cycle and incorporated process mapping, root cause analysis and data analysis techniques. The redesigned process reorganized the workflow into five structured phases composed of 45 detailed activities and incorporated inspection decision points to improve process control. Based on estimated rework metrics, the redesigned workflow demonstrated the potential to reduce annual rework time from 1,600 to 667 hours, representing an estimated 58.3% reduction.

Introduction

The project was conducted in a department at an aerospace company that consists of a team of engineers specializing in the design of equipment for assembling and disassembling aircraft engines using computer-aided design (CAD) software. The existing process flow map of the design process was structured around broad phases rather than clearly defined activities, which led to inconsistencies in how team members executed tasks.

Problem

Over a 12-month period, approximately two out of five projects required rework due to missed steps or incorrect sequencing. Additionally, the lack of process granularity created challenges in resource balancing, contributing to bottlenecks at inspection points and an increase in work-in-progress task inventory.

Methodology

The project applied the PDCA methodology to support continuous improvement in alignment with AS9100D quality management requirements for the aerospace industry.

Plan Phase

The Plan phase focused on understanding the existing process and defining the improvement strategy. The problem was identified and structured using 5W2H framework. Historical data from the information system — including task durations and rework time — were collected and analyzed. Root cause analysis was performed using a fishbone diagram, Figure 1, and the 5 Whys technique to understand variability and rework causes. Process-related factors were the primary contributors to inconsistent task execution. Improvement ideas were generated and grouped through affinity diagrams, promoting team participation and identification of priority areas for process redesign.

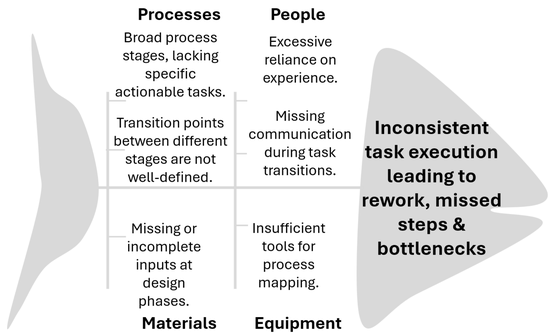

Figure 1. Fishbone Diagram

Do Phase

In the Do phase, the design process was redesigned through iterative refinement. The workflow was decomposed into detailed activities using process mapping techniques. The redesign activities were conducted in three review segments from the original design flow map: (1) start to concept (2) concept to preliminary and (3) preliminary to final delivery. The final process flow map was then released and made accessible through a shared platform.

Check Phase

The Check phase evaluated the effectiveness of the redesigned process through process observations and Gemba Walks. Performance data related to tasks that required rework due to unclear process definition or missed activities were collected and analyzed with rework time.

Act Phase

In the Act phase, the redesigned process was standardized and controlled. A control plan was developed to support the sustained application of the new process, including documentation updates and the capture of lessons learned.

Results

Variability in Task Duration

The box plot shown in Figure 2 supported the need to improve and standardize the design process. The data showed a wide dispersion in task duration, ranging from approximately 14 to 225 hours. The interquartile range, between approximately 57 and 155 hours, also indicated substantial variability in task execution. The median and mean values were closely aligned, suggesting a stable central tendency.

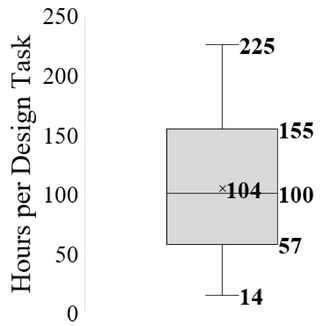

Figure 2. Distribution of Hours Per Design Task

Process Redesign and Activity Decomposition

The previous workflow was structured around broad process phases with limited activity definition, as illustrated in Figure 3.

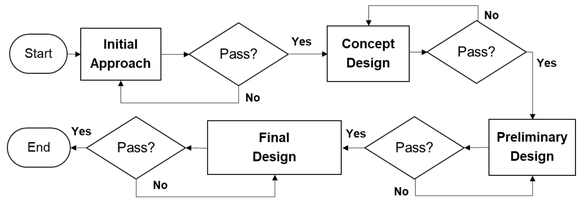

Figure 3. Previous Design Process Flow Map

Figure 4 present the redesigned process flow map developed during this project.

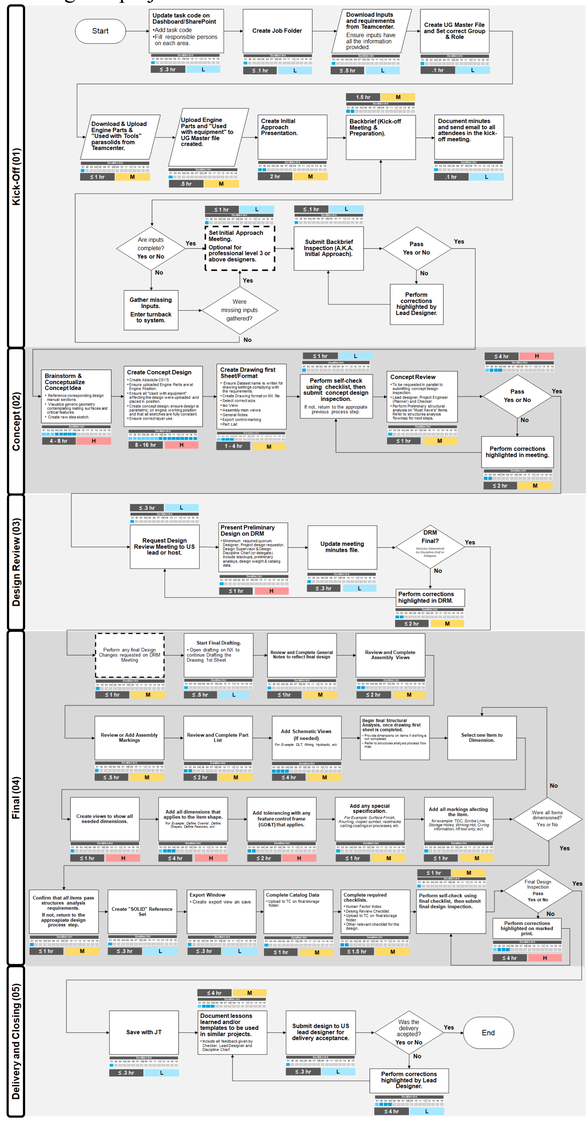

Figure 4. Redesigned Process Flow Map

The design process was redesigned into five structured phases composed of 45 detailed activities with defined sequencing, estimated durations, complexity classifications and inspection decision points, improving workflow clarity, process control and execution consistency.

Table 1 summarizes the estimated duration distribution of the redesigned activities. The results indicated that approximately 80% of the activities were designed with durations below two hours.

Table 1. Distribution of Estimated Activity Durations

Activity Duration (hours)	Count	Percent
(0,1]	28	62%
(1,2]	8	18%
(2,4]	7	16%
(4,8]	1	2%
(8,16]	1	2%

Conclusions

The redesigned process reduced the estimated annual rework time from 1,600 to 667 hours, as shown in Table 2, representing an estimated reduction of approximately 58.3%. This reduction demonstrated the potential operational benefits of granular activity definition, reducing non-value-added activities and improving process predictability.

Table 2. Reduction in Annual Rework Time

Process Flow Type	Tasks with Rework (A)	Average Rework Time (hours per design) (B)	Planned Designs (designs per year) (C)	Calculated Annual Rework Time (hours per year) (A)×(B)×(C)
Phase Based	40.0%	20	200	1600
Activity Based	16.7%	20	200	667

Future Work

Future improvement efforts must incorporate task quantity and complexity metrics into the historical data collection process, since factors such as drawing count, number of designed items and perceived technical complexity were not captured in the existing data.

References

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